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FOR

TRANSCODING APPARATUS AND METHOD BETWEEN CELP-BASED CODECS USING BANDWIDTH EXTENSION

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TRANSCODING APPARATUS AND METHOD BETWEEN CELP-BASED CODECS USING BANDWIDTH EXTENSION

This application claims priority from Korean Patent Application No. 2002-77769, filed December 9, 2002, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to code-excited linear prediction (CELP)-based voice coding, and more particularly, to a transcoding apparatus and method between CELP-based codecs using bandwidth extension from a narrowband to a wideband.

2. Description of the Related Art

A technology to transmit voice in the form of digital signals is widely used in wireless telecommunications and in voice over IP (VoIP) networks, which have been attracting much attention recently, in addition to wired telecommunications such as the conventional telephone networks. If voice is simply sampled, digitized, and then transmitted, a data transmission rate of about 64kbps (in the case of sampling at 8kHz and coding each sample with 8 bits) is needed. However, if voice analysis and appropriate coding are used, voice can be transmitted at a much lower transmission rate.

An apparatus which extracts parameters from a voice production model and compresses voice is usually referred to as a vocoder. This apparatus comprises a coder which analyzes voice in order to extract parameters from input voice, and decoder which re-synthesizes voice from parameters transmitted through a transmission channel. Voice is divided into units of blocks referred to as a frame (or subframe) on time axis and then processed.

A linear prediction-based time-domain vocoder has been widely used till recently. This linear prediction technique is a method by which correlations of a current sample to past samples are extracted and only those parts that have

no relation with the past samples are encoded. A basic linear prediction filter predicts a current sample with linear combination of past samples.

The function of a vocoder is to compress a voice signal at a low bit rate by removing redundancy existing in voice itself. Generally, voice has short-term redundancy due to filtering actions of a mouth and a tongue, and long-term redundancy due to vibration of the vocal chords. In a CELP coder, these two actions are modeled with respective filters, referred to as a short-term formant filter and a long-term pitch filter, respectively. Through these two filters, redundancies of a signal are removed and the remaining signal is modeled as white Gaussian noise or multi-pulse and the like and encoded.

The base of this technology is calculation of parameters of the two digital filters. The formant filter or linear predictive coding (LPC) filter performs a short-term prediction process of a voice waveform, while the pitch filter performs a long-term prediction process. One of excitation signals which make a signal finally synthesized the closest to the original voice signal is determined in an excitation codebook. Accordingly, parameters transmitted through a channel are broken down into three types, a formant (or LPC) filter coefficients, a pitch filter coefficients, and an excitation codebook index.

FIG. 1 is a schematic block diagram of an ordinary CELP vocoder comprising a encoder 102, a channel 104, and a decoder 106. Here, the channel 104 can be a communication channel, a storage medium and the like. The encoder 102 receives digitized input voice, extracts parameters expressing the characteristic of the voice, quantizes the result, and generates a bitstream to be transmitted through the channel 104. The decoder 106 restores the voice waveform from the received bitstream.

Meanwhile, various types of CELP vocoders are in use now. In order to successfully decode a bitstream encoded in a predetermined CELP format, the same CELP model as the encoder should be applied. If different communications networks employ their own CELP codecs, they need an apparatus for converting one CELP format into another CELP format.

FIG. 2 is a block diagram of a tandem coding system for converting an input CELP format into an output CELP format having different voice

bandwidths respectively. The system comprises an input CELP format decoder 202, a voice bandwidth converter 204, and an output CELP format encoder 206. The input CELP format decoder 202 decodes an input bitstream in order to re-synthesize the original voice. The voice bandwidth converter 204 converts the sampling frequency of voice so that the voice re-synthesized in the input CELP format decoder 202 fits an output format. The output CELP format encoder 206 again encodes the voice, whose bandwidth was converted in the voice bandwidth converter 204, into an output CELP format.

This tandem coding method has shortcomings of voice quality degradation, delay increase, and computational complexity increase that occur because of many steps of the encoder and decoder. In addition, when transcoding from a narrowband codec format to a wideband codec format is performed, high quality voice cannot be transmitted because it simply changes a sampling frequency and therefore lacks information on a high band.

SUMMARY OF THE INVENTION

The present invention provides a transcoding apparatus and method between CELP-based codecs using bandwidth extension, by which when transcoding from a narrowband CELP-based codec to a wideband CELP-based codec is performed, encoding efficiency is increased and by generating voice information corresponding to the high band of wideband voice, high quality voice can be transmitted.

The present invention also provides a computer readable medium having embodied thereon a program code for executing the transcoding method in a computer.

According to an aspect of the present invention, there is provided a transcoding apparatus between code-excited linear prediction (CELP)-based codecs using bandwidth extension, the apparatus comprising a parameter converter which extracts formant parameters in a narrowband CELP format from an input narrowband bitstream, and converts the extracted formant parameters into formant parameters in a wideband CELP format; an excitation signal parameter converter which converts excitation signal parameters in a

narrowband CELP format of an input narrowband bitstream, into excitation signal parameters in a wideband CELP format; and a quantizer which quantizes the wideband CELP format formant parameters converted in the formant parameter converter and the wideband CELP format excitation signal parameter converted in the excitation signal parameter converter, respectively, in an output CELP format.

According to another aspect of the present invention, there is provided a transcoding method between CELP-based codecs using bandwidth extension, the method comprising: (a) extracting formant parameters in a narrowband CELP format from an input narrowband bitstream, and converting the extracted formant parameters into formant parameters in a wideband CELP format; (b) converting excitation signal parameters in a narrowband CELP format of an input narrowband bitstream, into excitation signal parameters in a wideband CELP format; and (c) quantizing the wideband CELP format formant parameters and the wideband CELP format excitation signal parameter, respectively, in an output CELP format.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a schematic block diagram of an ordinary CELP vocoder;

FIG. 2 is a block diagram of a conventional tandem coding system for converting an input CELP format into an output CELP format employing different voice bandwidth respectively;

FIG. 3 is a schematic block diagram of a transcoding apparatus from a narrowband CELP format bitstream to a wideband CELP format bitstream according to a preferred embodiment of the present invention;

FIG. 4 is a flowchart of a formant parameter conversion process performed in a formant parameter converter of the apparatus shown in FIG. 3;

FIG. 5 is a schematic block diagram of a formant bandwidth extender shown in FIG. 3;

FIG. 6 is a flowchart showing in detail an order conversion process performed in a formant order converter shown in FIG. 3;

FIG. 7 is a flowchart showing a frame rate conversion process performed in a formant frame rate converter shown in FIG. 3;

FIG. 8 is a flowchart showing an excitation signal parameter conversion operation performed in an excitation signal parameter converter shown in FIG. 3; and

FIG. 9 is a block diagram of a preferred embodiment of an excitation signal bandwidth extender shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 3, the transcoding apparatus according to the present invention comprises a formant parameter converter 340, a formant coefficient quantizer 308, an excitation signal parameter converter 380, and an excitation signal quantizer 326.

Referring to FIG. 3, the formant parameter converter 340 converts a formant filter coefficient in a narrowband CELP format into a wideband CELP format in order to obtain a wideband formant parameter. More specifically, the formant parameter converter 340 comprises a formant bandwidth extender 302, a formant order converter 304, a formant frame rate converter 306, and 1st through 4th formant type converters 320A through 320D.

The 1st formant type converter 320A converts a types of narrowband formant parameter obtained from the input CELP bitstream into a type appropriate to the formant bandwidth extender 302, for example, a line spectral frequency (LSF). A bandwidth relates to the sampling frequency of voice and generally corresponds to a half of a sampling frequency. In order to transcode a formant parameter from a narrowband to a wideband (for example, in a case where one is a narrowband codec spanning from 0 Hz to 4kHz band and the other is a wideband codec), a bandwidth extension process in a formant filter coefficient domain is needed. If formant coefficients from an input bitstream are the LSF type, it is not needed to pass the 1st formant type converter 320A.

The formant bandwidth extender 302 receives LSF coefficients from the

formant type converter 302, and extends their bandwidth from a narrowband to a wideband. The formant bandwidth extender 302 will be explained in detail referring to FIG. 5.

The 2nd formant type converter 320B receives the bandwidth-extended formant filter coefficients from the formant bandwidth extender 302, and converts their type into a formant coefficient type appropriate to order conversion, for example, into a reflection coefficient.

The formant order converter 304 receives the reflection coefficients converted in the 2nd formant type converter 320B, and converts the order of the reflection coefficient into an order specified in an output CELP format. The order conversion process performed in the formant order converter 304 will be explained in detail referring to FIG. 6.

The 3rd formant type converter 320C converts a type of the filter coefficients order-converted in the formant order converter 304, into a coefficient type appropriate to frame rate conversion, for example, into a line spectral pair (LSP) coefficient.

The formant frame rate converter 306 converts the frame rate of the LSP coefficients converted in the 3rd formant type converter 320C so that it fits the frame rate of the output CELP format. For the frame rate conversion, if CELP-based codecs use different frame size that is an analysis unit for voice in a CELP-based codec, the frame size should be adjusted to fit an output format for transcoding between such codecs. This means adjusting the number of frames analyzed per second between an input codec and an output codec. The frame rate conversion process performed in the formant frame rate converter 306 will be explained in detail referring to FIG. 7.

The 4th formant type converter 320D converts a type of the filter coefficient which is frame rate converted by the format frame rate converter 306, into a type of an output CELP format. If the output CELP codec uses an LSP type, this step is not needed.

Next, the formant coefficient quantizer 308 quantizes the formant filter coefficients of the output CELP format converted in the 4th formant type converter 320D through a way used in the output CELP codec.

The excitation signal parameter converter 380 converts an excitation signal parameter in a narrowband CELP format into a wideband CELP format in order to obtain a wideband excitation signal parameter. More specifically, the excitation signal parameter converter 380 comprises an excitation signal synthesizer 312, an excitation signal bandwidth extender 314, a formant coefficient interpolator 316, a perceptual weighted filter (PWF) 318, an adaptive codebook searcher 322, a fixed codebook searcher 324, and fifth and sixth formant type converters 320E, 320F.

The excitation signal synthesizer 312 extracts an excitation signal parameter from a narrowband bitstream in a narrowband CELP format, and by using the extracted excitation signal parameter, synthesizes a narrowband excitation signal. Generally, excitation signal parameters include an adaptive codebook index corresponding to a pitch component, and the gain of the codebook, and a fixed codebook index and the gain of the codebook, and the like. By using these parameters, the excitation signal synthesizer 312 synthesizes an excitation signal according to a method used in an input CELP format decoder.

The excitation signal bandwidth extender 314 converts the narrowband excitation signal synthesized in the excitation signal synthesizer 312, into an excitation signal corresponding to the bandwidth of a wideband CELP formant. The excitation signal bandwidth extender 314 will be explained in detail referring to FIG. 9.

The 5th formant type converter 320E converts a type of the frame rate converted formant filter coefficients into a type appropriate to formant coefficient interpolation for the following subframe processing, for example, LSP type.

The formant coefficient interpolator 316 obtains formant coefficients corresponding to a subframe analysis unit through interpolation, according to an analysis unit of an excitation signal. Generally, a formant parameter exists in a frame unit, an excitation parameter exists in each subframe unit, and two or more subframes are in one frame. Accordingly, the formant coefficient interpolator 316 interpolates formant coefficients in a frame unit so as to obtain formant coefficients in subframe unit.

The 6th formant type converter 320F receives LSP coefficients corresponding to each subframe interpolated in the formant coefficient interpolator 316, and converts the LSP type into a formant type appropriate to the PWF 318, for example, into an LPC coefficient.

The PWF 318 is a filter for filtering the bandwidth extended excitation signal so that the resulting signal reflects the human perception characteristic. The PWF 318 is constructed using the LPC coefficients corresponding to a subframe converted in the 6th formant type converter 320F, and filters the excitation signal having the bandwidth of the wideband CELP format converted in the excitation signal bandwidth extender 314. By passing the bandwidth extended excitation signal through the PWF 318, the signal is converted into a signal reflecting the human perception characteristic.

Using the output signal of the PWF 318 as a target signal, the adaptive codebook searcher 322 searches a codebook corresponding to pitch information and calculates the corresponding adaptive codebook gain. This adaptive codebook searching process is identically performed as the output CELP codec does.

Subtracting the contribution of the adaptive codebook from the output signal of the PWF 318, the target signal for fixed codebook search is obtained. The fixed codebook searcher 324 searches the fixed codebook for the output CELP codec, and calculates the corresponding fixed codebook gain. This fixed codebook searching process is also identically performed as the output CELP codec does.

Next, the excitation signal quantizer 326 receives the codebook indexes and gains generated in the adaptive codebook searcher 322 and the fixed codebook searcher 324, as excitation parameters, and quantizes them in the output CELP codec format.

FIG. 4 is a flowchart of a formant parameter conversion process performed in the formant parameter converter of the apparatus shown in FIG. 3.

Referring to FIGS. 3 and 4, the formant type converter 320A converts a type of the formant filter coefficient, into a coefficient type appropriate to formant bandwidth extension, for example, an LSF coefficient, in step 402. At this time,

if the coefficient type of the input narrowband bitstream is the LSF, this process is not needed.

After the step 402, the formant bandwidth extender 302 receives the LSF coefficients from the formant type converter 320A, and extends the bandwidth of the formant coefficients from a narrowband to a wideband to fit them to the output CELP format in step 404.

After the step 404, the second formant type converter 320B converts a type of the bandwidth extended formant filter coefficients into a formant coefficient type appropriate to order conversion, for example, a reflection coefficient, in step 406.

After the step 406, the formant order converter 304 converts the order of the reflection coefficients converted in the step 406, into an order of a model used in the output CELP format in step 408.

The 3rd formant type converter 320C converts a type of the filter coefficients, which is order-converted in the step 408, into a coefficient type appropriate to frame rate conversion, for example, an LSP coefficient, in step 410.

After the step 410, the frame rate converter 306 converts the frame rate of the LSP coefficients converted in the step 410, to fit them to the frame rate of the output CELP format in step 412.

After the step 412, the 4th formant type converter 320D converts the frame rate converted filter coefficients in the LSP format, into a formant filter coefficients type in the output CELP format in step 414. If the output CELP codec uses LSP type, this process is not needed.

After the step 414, the formant coefficient quantizer 308 quantizes the formant filter coefficients converted in the step 414 through a way used in the output CELP codec.

FIG. 5 is a schematic block diagram of the formant bandwidth extender 302 shown in FIG. 3, comprising a formant coefficient scaling unit 502, a formant coefficient concatenation unit 504, a narrowband codebook searching unit 506, a wideband codebook searching unit 508, and a codeword truncation unit 510.

The formant coefficient scaling unit 502 first scales narrowband formant coefficients sent by the first formant type converter 320A (Refer to FIG. 3), to fit them to a wideband formant parameter format, and obtains a formant coefficients corresponding to a low band. For example, if a narrowband CELP codec spans a bandwidth from 0Hz to 4kHz and a wideband CELP codec spans a bandwidth from 0Hz to 8kHz, the scaling factor at the LSF (in radian) domain is 0.5(= 4kHz / 8 kHz).

By using the resulting low band formant coefficients from the formant coefficient scaling unit 502 and referring to a narrowband codebook 512 trained in advance, the narrowband codebook searching unit 506 finds an index for a closest codeword and provides the index to the wideband codebook searching unit 508.

Referring to a wideband codebook 514, the wideband codebook searching unit 508 searches for a wideband codeword corresponding to the index found by the narrowband codebook searching unit 506. Generally, low band voice information (e.g. 0~4kHz) relates to high band voice information (e.g. 4~8kHz). Accordingly, using the low band codeword index provided by the narrowband codebook searching unit 506, the wideband codebook searching unit 508 can search for a wideband codeword.

The codeword truncation unit 510 truncates the wideband codeword found in the wideband codebook searching unit 508 so that only the component corresponding to the high band of the wideband remains. Thus, through the wideband codebook searching unit 508 and the codeword truncation unit 510, voice information of the high band can be generated.

By adding the low band formant coefficients obtained in the format coefficient scaling unit 502 and the high band formant coefficients obtained in the codeword truncation unit 510, the formant coefficient concatenation unit 504 generates a bandwidth extended wideband formant coefficients.

Meanwhile, in order to obtain the narrowband codebook 512 and the wideband codebook 514, a predetermined training process is needed.

Referring to FIG. 5, first, a narrowband voice database 532 is generated from a prepared wideband voice database 544 through a sampling frequency

conversion unit 542.

1st and 2nd linear predictive coding (LPC) analysis unit 534 and 546 obtain LPC coefficients through the linear predictive coding analysis method respectively, from the narrowband voice DB 532 and the wideband voice DB 544.

1st and 2nd coefficient type conversion units 536 and 548 convert LPC coefficients obtained by the 1st and 2nd linear predictive coding analysis units 534 and 546, respectively, into formant coefficients appropriate to codebook training. Through theses processes, formant coefficients sets corresponding to the narrowband voice DB 532 and the wideband voice DB 544, respectively, are generated.

A 1st vector quantization unit 538 quantizes narrowband formant coefficients vectors and generates a narrowband codebook 540 having a desired number of representative values (codewords). This vector quantization can be performed using the famous LBG (Linde, Buzo, and Gray) algorithm.

A 2nd vector quantization unit 550 generates a wideband codebook 552 using the class information on each formant coefficient vectors additionally obtained in the process for generating the narrowband codebook 540. Thus the obtained codebook pair 540 and 552 can be referred to by an identical index.

FIG. 6 is a flowchart showing in detail an order conversion process performed in the formant order converter 304 shown in FIG. 3.

Referring to FIG. 6, if an input order is greater than an output order in step 602, the input order is decimated to fit the output order in step 606. Here, the decimation process in the step 606 can be simply performed by replacing unnecessary coefficients greater than the output model order with zeros.

If the input order is less than the output order in step 604, the input order is interpolated to fit the output order in step 608. Here, the interpolation process in the step 608 can be performed by filling the same number of zeros as the lacked order. If the input order is the same as the output order, this order conversion process is not needed and is omitted in step 610.

FIG. 7 is a flowchart showing a frame rate conversion process performed in the formant frame rate converter 306 shown in FIG. 3.

Referring to FIGS. 3 and 7, if an input frame rate is higher than an output frame rate in step 702, the formant frame rate converter 306 decimates the input LSP coefficients to fit them to the output frame rate in step 706.

If the input frame rate is lower than the output frame rate in step 704, the formant frame rate converter 306 interpolates the input LSP coefficients to fit them to the output frame rate in step 708. Here, in the decimation step 706 of the LSP coefficients, the output formant coefficients can be obtained, by applying appropriate weighting values compensating the frame rate mismatch to input formant coefficients of a current frame and those of previous frames, and then adding the coefficients. For example, if input CELP codec uses 10ms frame size (e.g. frame rate is 100 frames per second) and the output CELP codec uses 20ms frame size (e.g. frame rate is 50 frames per second), the following equation can be applied for decimation step:

$$lsp_{out}^{(i)} = \alpha \cdot lsp_{current}^{(i)} + (1-\alpha) \cdot lsp_{previous}^{(i)}$$

where, lsp_{out} is the output formant coefficient of the frame rate converter, $lsp_{current}$ is the input formant coefficient in the current frame, and $lsp_{previous}$ is the input formant coefficient in the previous frame. i indicates the order index and α is a weighting factor.

Also, in the interpolation step 708 of the LSP coefficients, frame rate converted LSP coefficients can be obtained by applying appropriate weighting values to the input formant coefficients of a previous frame and the input formant coefficients of a current frame and summing the weighted coefficients. For example, if input CELP codec uses 20ms frame size (e.g. the frame rate is 50 frames per second) and the output CELP codec uses 10ms frame size (e.g. the frame rate is 100 frames per second), the following equation can be applied for interpolation step:

$$lsp_{out1}^{(i)} = \alpha \cdot lsp_{current}^{(i)} + (1-\alpha) \cdot lsp_{previous}^{(i)}$$
$$lsp_{out2}^{(i)} = \beta \cdot lsp_{current}^{(i)} + (1-\beta) \cdot lsp_{previous}^{(i)}$$

where, lsp_{out1} is the first output formant coefficient of the frame rate converter, lsp_{out2} is the second output formant coefficient of the frame rate converter, $lsp_{current}$ is the input formant coefficient in the current frame, and $lsp_{previous}$ is the input formant coefficient in the previous frame. i indicates the order index, and α and β are weighting factors.

If the input frame rate is the same as the output frame rate, this process is not needed and is omitted in step 710.

FIG. 8 is a flowchart showing an excitation signal parameter conversion operation performed in the excitation signal parameter converter 380 shown in FIG. 3.

Referring to FIGS. 3 and 8, the excitation signal synthesizer 312 extracts excitation signal parameters from the input CELP format narrowband bitstream and using the extracted excitation signal parameters, synthesizes a narrowband excitation signal in step 802.

After the step 802, the excitation signal bandwidth extender 314 converts the narrowband excitation signal synthesized in the step 802, into an excitation signal corresponding to the bandwidth of the wideband CELP format in step 804.

Meanwhile, the 5th formant type converter 320E converts a type of the frame rate converted formant filter coefficients into a coefficient type appropriate to formant coefficient interpolation in step 814. The formant type converter 320E may pass the frame rate converted LSP coefficient without change.

After the step 814, according to a predetermined frame analysis unit, the formant coefficient interpolator 316 obtains formant coefficients corresponding to the each subframe analysis unit, through interpolation in step 816. For example, when the excitation signal is analyzed in units of subframes, the formant coefficients corresponding to each subframe are obtained through the interpolation. More specifically, by interpolating between the LSP coefficients of the previous frame and the LSP coefficients of the current frame with applying an appropriate weighting value for each subframe, a formant

coefficients corresponding to each subframe can be obtained. This process is similar to the interpolation step 708 in the formant frame rate converter 306.

The 6th formant type converter 320F receives the LSP formant coefficients corresponding to each subframe interpolated in the step 816, and converts them into coefficients in a formant filter type appropriate for the PWF, for example, an LPC coefficient, in step 818.

The PWF 318 is constructed from the LPC coefficients corresponding to the subframe converted in the step 818, and filters the excitation signal having the bandwidth of the wideband CELP format converted in the step 804, in step 806. Thus, using the PWF 318, the excitation signal is converted to a signal reflecting the human perception characteristic.

After the step 806, regarding the output signal of the PWF 318 as a target signal, the adaptive codebook searcher 322 searches for a codebook corresponding to pitch information to fit the output CELP format, and calculates the corresponding codebook gain in step 808. This adaptive codebook searching process is identically performed as the output CELP codec does.

Also, after the step 806, subtracting the contribution of the adaptive codebook from the output signal of the PWF 318, the target signal for fixed codebook search is obtained. The fixed codebook searcher 324 searches for the fixed codebook to fit the output CELP format, and calculates the gain of the corresponding codebook in step 810. This fixed codebook searching process is also identically performed as the output CELP codec does.

FIG. 9 is a block diagram of a preferred embodiment of an excitation signal bandwidth extender 314 shown in FIG. 3. The excitation signal bandwidth extender according to a preferred embodiment comprises a high band reproducing unit 904, a high pass filter 906, a sampling frequency conversion unit 902, and an adder 908.

Referring to FIG. 9, the sampling frequency conversion block 902 converts a narrowband excitation signal sent by the excitation signal synthesizer 312, into a low band excitation signal having a sampling frequency corresponding to the wideband CELP format. The sampling frequency conversion unit 902 comprises an up-sampling and low band pass filters as

generally well known.

The high band reproducing unit 904 regenerates an excitation signal component corresponding to the high band of the wideband, from the original narrowband excitation signal sent by the excitation signal synthesizer 312. As a high band reproducing method, the well known methods such as spectrum folding and non-linear distortion can be used.

The high pass filter 906 passes only the high band of the excitation signal reproduced in the high band reproducing unit 904, and obtains an excitation signal component corresponding to the high band of the overall wideband excitation signal.

The adder 908 adds the low band excitation signal generated in the sampling frequency converter 902 and the high band excitation signal generated in the high pass filter 906, and generates a wideband excitation signal.

The present invention may be embodied in a code, which can be read by a computer, on a computer readable recording medium. The computer readable recording medium includes all kinds of recording apparatuses on which computer readable data are stored. The computer readable recording media includes storage media such as magnetic storage media (e.g., ROM's, floppy disks, hard disks, etc.), optically readable media (e.g., CD-ROMs, DVDs, etc.) and carrier waves (e.g., transmissions over the Internet). Also, the computer readable recording media can be scattered on computer systems connected through a network and can store and execute a computer readable code in a distributed mode.

Optimum embodiments have been explained above and are shown. However, the present invention is not limited to the preferred embodiment described above, and it is apparent that variations and modifications by those skilled in the art can be effected within the spirit and scope of the present invention defined in the appended claims. Therefore, the scope of the present invention is not determined by the above description but by the accompanying claims.

According to the transcoding apparatus and method between CELP-

based codecs using bandwidth extension of the present invention as described above, degradation of voice quality, delay, and computation load can be minimized, and by additionally generating information corresponding to the high band of wideband voice, high quality voice communication between networks having different bandwidths is enabled.